3

Development of Mode Alternatives

3.1 Introduction

For the analysis of potential improvements for I-93 between Salem and Manchester, an evaluation of alternative transportation modes was conducted. These alternative modes include rail services, bus services, and HOV lanes. The objective for analyzing these other modes was to understand how they may complement and minimize the need for highway improvements.

This chapter describes the individual HOV, rail, and bus modes considered. It also reviews the methodology used to project rail, bus and HOV ridership, and presents the results of the analysis of potential ridership for the various modes.

The mode options that were analyzed include four rail options, two HOV lane options, and two bus options. Following establishment of parameters describing the capabilities and limits of each option, all the options were preliminarily tested individually with the assumption that I-93 was widened to four lanes in each direction. All analyses also included the assumption that the extension of commuter rail service from Lowell to Nashua is operational.

The mode options analyzed were chosen based on technology, financing, and infrastructure that are available today or are plausibly feasible. The intent was to test the ridership potential of alternative modes under favorable but realistic conditions. The parameters used to define the options did not necessarily limit the capacity of the various options. For example, sufficient parking was assumed at each bus or rail station to accommodate all potential demand at the station. Similarly, a sufficient number of cars per train or buses were assumed to be available to satisfy projected demand.

Based on the preliminary analysis results, those mode options deemed feasible and practicable were combined with each other and various highway lane configurations (i.e., two, three, or four general use lanes in each direction). Fourteen mode combinations were identified to test the potential interaction between rail, bus, HOV and highway options and to determine how the ridership generated by these different combinations of mode options might influence the need for highway improvements. Chapter 5 presents projections of ridership for these combinations of other modes and highway widening options.

3.2 High Occupancy Vehicle Lanes

HOV facilities provide lanes dedicated to vehicles carrying more than one person. The number of people required per vehicle and the time periods the lanes are so dedicated are dependent on the demand for the lanes. To be successful, HOV lanes must not be congested or there will be little incentive for drivers of single occupancy vehicles (SOV) to consider ride-sharing or bus services. In addition, the HOV lane must not be under-utilized, or motorists in general use lanes will question the merit of having HOV lanes. Possible HOV lane configurations include concurrent flow lanes and a single exclusive reversible (contra-flow) lane.

Two I-93 HOV lane options were preliminarily developed. The parameters and assumptions defining these options are:

➤ One HOV lane in each direction on I-93 in New Hampshire from north of Exit 5 to the New Hampshire/Massachusetts state line. Access/egress would not be provided at either Exit 1 or 2 due to the proximity of the interchanges to each other and to the state line. Vehicles would be allowed to access/egress at all other exits.

  The geometric configuration of the lane was not a factor in the projection of ridership, but for the purposes of analyzing engineering and environmental impacts, a concurrent flow lane adjacent to three general purpose lanes was assumed. The cross section included a 14-foot inside enforcement shoulder, a 12-foot HOV lane, a four-foot painted buffer, three 12-foot general purpose lanes, and an outside shoulder lane.

➤ One HOV lane in each direction on I-93 from north of Exit 5 in New Hampshire to I-95 (Route 128) or the Woburn Interchange in Massachusetts. This scenario assumes that vehicles can access/egress the HOV lane at each New Hampshire interchange. The roadway cross section is the same as for the first alternative and includes a concurrent flow lane adjacent to three general purpose lanes.

3.3 Passenger Rail Service

Mode Options developed for the I-93 Salem – Manchester corridor include four rail alternatives along three basic rail alignments (see *Rail Alternatives Evaluation Report*, VHB, November 13, 2000). These rail alternatives are primarily focused on providing commuter service to Boston, MA thereby relieving auto congestion along the I-93 highway corridor during peak periods. The alternatives developed include commuter rail service along the New Hampshire Main Line (West Rail Corridor from Manchester to Lowell, MA via Bedford, Merrimack and Nashua); commuter rail service along the Manchester & Lawrence Branch (East Rail Corridor from Manchester to Lawrence, MA) with two optional alignments near the Manchester Airport; and two light rail services along the I-93 highway right-of-way -beginning near Exit 5 or the Manchester Airport, and continuing along I-93 south of Exit 1, where it would connect either to Lawrence, MA (I-93 Basic Rail Corridor) or to the Woburn Transportation Center in Woburn, MA (I-93 Enhanced Rail Corridor). The following sections summarize the rail alternatives developed.

3.3.1 East Rail Corridor

The East Rail Corridor principally follows the Manchester and Lawrence Branch (M&L), which is for the most part, an abandoned 28-mile rail line (Figure 3.3-1) that runs north-south from Manchester, NH to Lawrence, MA. The M&L branches from the New Hampshire Main Line (West Rail Corridor) in the Manchester Freight Yard, which is just south of the site of the former Manchester Station. From there the line runs south toward Manchester Airport. In the area of the airport, two options have been considered for this corridor, due to the recent extension of Runway 6-24 across the railroad right-of-way. One option (Option 1) is to construct a tunnel underneath the runway within the former existing railroad right-of-way. The other option (Option 2) is to relocate the rail line around the airport creating a new railroad right-of-way. After passing by the Airport the rail line continues south through Londonderry, Derry, Windham and Salem, east of I-93, to Lawrence, Massachusetts where it connects to the Massachusetts Bay Transit Authority's (MBTA) Haverhill Line.

A majority of the M&L rail corridor in New Hampshire is owned by the State. Some portions that have been sold to towns or private land owners. A short portion of the line between the state line and Salem is owned by Guilford Transportation Industries (GTI) through the Boston & Maine Corporation. Presently, the only traffic on the line is occasional freight service between Lawrence and Salem operated by Springfield Terminal Railway, a subsidiary of GTI. In Massachusetts, the line is owned by the MBTA.

The East Rail Corridor service would be a commuter rail shuttle service between Manchester and Lawrence with intermediate stations located near I-93 Exit 5 in Londonderry, and I-93 Exit 1 in Salem. Standard commuter rail equipment would be used for the service between Manchester and Lawrence. At the existing MBTA Lawrence Station, passengers would transfer to commuter rail trains on the Haverhill Line and continue south through Andover and on to Boston. Total travel time between Manchester and Boston would average 94 minutes.

The rail service alternative has been developed as a shuttle instead of through service primarily due to the lack of capacity on the MBTA's Haverhill Line. There is currently a 12-mile segment of single-track railroad between Andover and Reading, which limits the number of trains the MBTA can operate north of Reading to Lawrence and Haverhill. Approximately half of the existing weekday Haverhill Line service terminates at Reading because of the capacity constraint. Therefore, it was assumed that any new service on the M&L would terminate at Lawrence requiring the transfer.

To institute rail shuttle service along the East Rail Corridor between Manchester and Lawrence will require capital improvements through the reconstruction of much of the existing track structure (rail, ties, ballast, sub-grade), bridges, grade crossings, and signal and communications system. Additionally, depending upon the specific rail alignment taken near Manchester Airport, a 1,300-foot rail tunnel under the runway or a 5 mile relocation of the rail corridor around the runway on a new alignment would be required.

Equipment required for the service would vary depending on the amount of service provided. For both options using this corridor three service levels were considered. The high level of service includes 12 weekday and 4 weekend roundtrips. The moderate level of service includes 8 weekday and 3 weekend roundtrips. The low level of service includes 6 weekday and 3 Saturday roundtrips. Since the rail service along the M&L Branch would be a shuttle from Lawrence to Manchester, integration with MBTA's northside commuter rail fleet would not be necessary. The trainsets, comprised of one locomotive and three coaches, would be dedicated to the New Hampshire service. Three sets of equipment will likely be required to operate either the Moderate or High Levels of Service with the Low Level of Service likely requiring only two sets of equipment.

3.3.2 West Rail Corridor

The New Hampshire Main Line (West Rail Corridor) runs in a north-south direction west of the I-93 highway corridor. From the site of the Manchester Station the rail line crosses the Merrimack River to Bedford and follows the river through Merrimack and Nashua to Lowell, Massachusetts. From Lowell the line continues south into Boston's North Station.

Daily freight traffic operated by Springfield Terminal Railway presently uses the line. Service from Lowell to the Nashua Yard consists of main line and local freight trains, as well as "unit coal" trains that head north to a power plant in Bow, NH. Train service north of Nashua consists primarily of trains serving local industries and the unit coal trains serving Bow. Mainline through freight trains also operate between Nashua and Boston in the late evening or very early morning hours. In March 1999, GTI was operating the unit coal train to Bow three days a week. Local freight service was operated daily from the Nashua Yard south to service customers located along the line to Lowell. Similarly, local freight service was offered daily from Nashua to the north.

Restoration of commuter rail service along this line is being approached in a two-phase program. Phase 1, which is presently progressing through Preliminary Engineering, includes an extension of service from the existing MBTA commuter rail terminus in Lowell to a new park and ride station located adjacent to F.E. Everett Turnpike at Exit 2 (Sagamore Bridge) in Nashua and to a station in downtown Nashua. The Phase 1 effort would extend service approximately 11 miles for the Exit 2 Station or up to 13 miles to reach downtown Nashua. Phase 2, which has been considered as a mode alternative for the I-93 corridor, would further extend service from the Exit 2 Station in Nashua to Manchester, a distance of 19 miles. Within this 19-mile segment, three potential station sites are being considered: Star Drive in Merrimack, the proposed Airport Access Road in Bedford, and Granite Street in Manchester.

The West Rail Corridor service would be typical commuter rail service operating with locomotive-hauled coaches between Manchester and North Station in Boston. This service would be an extension of the current MBTA Lowell Line service stopping at all stations along that line. The travel time between Manchester and Boston would average 83 minutes.

Commuter rail service along the West Rail Corridor between Manchester and Lowell will require a capital improvements through rehabilitation of the existing track structure (rail, ties, ballast, sub-grade), bridges, the signal and communications system, grade crossings, stations and support facilities, as well as construction of some new infrastructure.

Equipment needs for the West Rail Corridor service will vary depending on the amount of rail service provided. Three levels of service have been considered. The high level of service includes 12 weekday and 4 weekend roundtrips. The moderate level of service includes 8 weekday and 3 weekend roundtrips. The low level of service includes 6 weekday and 3 Saturday roundtrips. The service is likely to require between four and eight additional sets of equipment. The trainsets, comprised of one locomotive and seven coaches, would be part of the MBTA northside commuter rail fleet. This equipment would not be dedicated solely to the NH rail service, but would be rotated among the various northside rail services.

3.3.3 I-93 Rail Corridors

The third and fourth rail alternatives considered as part of the I-93 Salem – Manchester improvements involve constructing a new rail line within the existing I-93 highway corridor. As such, both alternatives would result in a rail line within the

I-93 highway corridor for 16.5 miles between Exit 5 in Londonderry and the Massachusetts state line. At the state line, for the I-93 Basic Rail Corridor, the rail alignment would leave the I-93 highway corridor and connect into the M&L Branch right-of-way continuing to Lawrence, MA. For the I-93 Enhanced Rail Corridor, the rail alignment would continue within the I-93 highway corridor through Massachusetts down to the Woburn Transportation Center. At the northern end for both rail corridors, near Exit 5, a connection would be made to the M&L Branch right-of-way along which a maintenance/layover facility would be sited. The Enhanced Option includes an extension of service to the Airport.

Due to the geometry of the I-93 corridor (i.e. the grades and curves) standard commuter rail is not a viable option. However, Light Rail vehicles can operate on grades up to 4 percent and on curve radii as tight as 83 feet, and consequently can negotiate curves and grades encountered within the I-93 highway corridor. The most likely light rail system to be used in this corridor is diesel light rail. This type of system, which is gaining favor in North America, does not require the construction of the electrified power system necessary to propel traditional light rail vehicles. The vehicles are propelled by diesel engines that are in each car. For the I-93 rail service these vehicles would operate in three car consists.

Due to safety considerations the equipment planned for this corridor cannot be used on the commuter rail line between Lawrence and Boston. Therefore, passengers would be required to transfer to the MBTA Haverhill Line in Lawrence for service to Boston or to the MBTA line in Woburn for service to Boston. Total travel time between Exit 5 in Londonderry and Boston would average 83 minutes for the I-93 Basic Rail Corridor and a similar travel time (depending on the number of stops in Massachusetts) for the I-93 Enhanced Rail Corridor. In New Hampshire, stations would be located near the Manchester Airport, at Exit 5 in Londonderry, Exit 4 in Derry, Exit 3 in Windham, and Exit 2 in Salem. The alignment would be primarily located in the highway median with it veering outside the median at times due to physical constraints.

The development of a light rail system along the I-93 corridor between Lawrence, MA and Londonderry would require substantial capital infrastructure improvements. The capital infrastructure program would include the construction of new track (rail, ties, ballast, sub-grade), bridges, grade crossings, and a signal and communications system along the entire corridor.

The levels of service considered for this corridor are similar to those of the other rail corridor alternatives developed for the study. This includes a high, moderate and low ranging from 12 to 6 daily weekday roundtrips between Exit 5 and Lawrence. These levels of service would require 6 vehicles for the low level of service and 9 vehicles for the moderate and high level of service.

3.4 Bus Service

Two bus services were evaluated as mode options. They included an expansion of existing commuter bus service to Boston and an Enhanced Bus Service to employment centers in northern Massachusetts. Both were combined with HOV options and the provision of a bus subsidy.

While two bus service options were developed, only the Expanded Bus service was included in the initial analysis of mode options. The Enhanced Bus service was subsequently included in the analysis of mode combinations as presented in Chapter 5. Both service options include the assumption that the planned extension of the MBTA's Lowell commuter rail line to Nashua is in service. The parameters and assumptions defining the two bus service options as well as the bus subsidy option are described in the following sections.

3.4.1 Expanded Bus Service

The Expanded Bus service is an expansion of the current Concord Trailways operation which provides service from Manchester and Londonderry (I-93 Exit 4) to Boston. The expanded bus operation would add service from Exits 5, 3 and 2 and would be served by new park and ride facilities at each location as described in Section 3.3 above. The park and ride facilities were assumed to have sufficient parking to accommodate all demand for bus service generated at each facility.

The number of stops in New Hampshire for each bus was kept low so that the total travel time could be minimized. The analysis assumed that it would take a bus two minutes to get off the highway, one minute to pick up passengers, and two minutes to get back on the highway. Every stop a bus makes adds five minutes to total travel time. Thus the bus service plan assumes that no individual bus would serve more than two locations, thus assuring that riders would at most have one stop before arriving in Boston.

3.4.2 Enhanced Bus Service

The Enhanced Bus service would provide access between New Hampshire and employment centers along the I-93 corridor in northern Massachusetts. The enhanced bus service includes two routes. The first route originates at Exit 5 and stops at Exit 4 while the second route would originate at Exit 4 and stop at Exit 3. As with the Expanded Bus service, sufficient parking was assumed to be available at each bus station. It was assumed that both routes would stop at Exit 45 (River Road), 42 (Dascomb Road), Exit 38 (Route 129) and Exit 37 (The Woburn Transportation Center) in Massachusetts.

As described under the Expanded Bus service, every stop a bus makes adds five minutes to total travel time. For this reason, a stop at Exit 2 was not included with this option because of the increase in travel time that would result. Some of the riders who would use an Exit 2 stop can use the Exit 3 stop. The number of passengers that would be lost (from Exits 5, 4, and 3) by adding an additional stop is expected to be about the same magnitude as the number that would be added by including a stop at Exit 2. In addition, an Exit 2 bus stop for riders to employment centers along I-93 in northern Massachusetts has less appeal given the relatively short distance between Exit 2 and the employment centers. Commuters are more likely to drive directly to the employment centers in such a situation rather than drive to a bus stop, switch, and take a bus.

3.4.3 Bus Fare Subsidy

A bus fare subsidy was also considered in the analysis of the Expanded and Enhanced Bus service options. The subsidized fare is $3.00 to $3.40 per one-way trip and is comparable to the current MBTA commuter rail fare. The reduced fare was designed to make the cost of commuter bus service competitive with commuter rail service and was set at the same level as commuter rail service as subsidized by the MBTA in Massachusetts.

3.5 Park and Ride Facilities

Park and ride facilities provide necessary support for HOV and transit services. Without adequate parking available, these services can not be utilized to the fullest extent. To support transit and HOV options, new park and ride facilities are planned at Exits 5, 3, and 2. The proposed facility at Exit 3 would replace the existing facility, which is underutilized because of its distance from the interchange and access problems. The existing park and ride facility at Exit 4 could be expanded if necessary to accommodate additional demand brought on by additional transit services.

The following sections describe the location and size of each facility, as currently envisioned. Each facility is located to support an expansion of bus service as well as commuter rail corridor service if instituted within the I-93 highway corridor. Each facility was sized to accommodate projected rail, bus and HOV ridership.

3.5.1 Exit 2 Park and Ride

The proposed park and ride concept developed for Exit 2 is located in the southeast interchange quadrant and is shown in Figure 3.5-1. Access for the facility will be provided via a new connector road to intersect with South Policy Street approximately 1400 feet south of the Pelham Road intersection and approximately 600 feet south of the Fairmont Road intersection. The facility will be located at the western limit of Fairmont Road and extend southerly along Boyer Lane, adjacent to the SB off-ramp.

This layout would involve approximately 9 parcels of land, several homes (some with potential historical significance) and approximately 9+/- acres of land. The Taylor Grist Mill, an historical site (signed as such), and other potentially historically important properties are located along Fairmont Road. This preliminary concept would allow for the construction of approximately 450-475 spaces with potential for expansion to the south to accommodate a future rail station. Concord Trailways, the current I-93 bus provider, in cooperation with the NHDOT, is looking at opportunities to provide increased transit services at this location. A pedestrian bridge will be required to access the future rail station platform in the median.

3.5.2 Exit 3 Park and Ride

The existing park and ride lot in Windham was upgraded in 1998 to further encourage travelers to use the facility. The lot is located on NH 111 approximately 0.8 miles west of I-93 with access provided via Wall Street. This existing facility provides parking for approximately 150 vehicles and was previously served by bus transit to Boston; however, this service was ended due to the lack of customers and the delay buses experienced in getting to and from I-93. The proposed new park and ride would serve as a replacement to this existing facility.

The proposed new park and ride concept developed for Exit 3 is located in the median area between the two barrels of I-93, conveniently closer to the highway. The median in the Exit 3 area is currently 1,000 feet wide and can accommodate this type of facility. Access will be provided via a new connector road intersecting with NH 111, approximately 600 feet east of the NH 111/SB ramps intersection. The facility will run parallel to the SB barrel of I-93, with approximately 100-200 feet separating the facility from the highway. The proposed Exit 3 park and ride concept is shown in Figure 3.5-2.

This layout would involve approximately 3-4 parcels of land and potentially one or two businesses. This preliminary concept would allow for the construction of approximately 600 parking spaces with the potential for future expansion to accommodate a rail station. Concord Trailways, in cooperation with the Department, is also looking at opportunities to provide increased transit services at this location. Access to a future rail line at Exit 3 would be direct.

3.5.3 Exit 4 Park and Ride

Exit 4 has an existing park and ride facility located in the northwest interchange quadrant, with access provided via Hampton Drive, approximately 1100 feet west of the NH 102/SB off-ramp intersection. This existing facility provides parking for approximately 470 vehicles and is currently served by Concord Trailways.

The proposed concept for Exit 4 would be an expansion to the existing facility. Access would be provided via an extension of the existing access road. The proposed expansion would be located at the end of Apple Tree Lane, approximately 0.5 miles north of the existing facility, and would run parallel to the SB barrel of I-93, with approximately 50-100 feet separating the facility from the highway. The existing facility and the proposed expansion concept for the Exit 4 park and ride concept is shown in Figure 3.5-3.

This layout would involve 2 parcels of land and approximately 20 acres. This preliminary concept would allow for the construction of approximately 575 parking spaces. Whether the proposed facility will eventually replace the existing facility is yet to be determined. A pedestrian bridge will be required to access the future rail station platform in the median from the new facility, similar to what would be required at Exit 2.

3.5.4 Exit 5 Park and Ride

Two proposed park and ride concepts have been developed for Exit 5. The first concept, Option 1, is located in the northwest interchange quadrant and is shown in Figure 3.5-4. The Option 1 park and ride is located on property primarily used by Spartan Consolidated, Inc., a waste transfer facility. The land needed to develop this facility would include approximately 16 acres from one private business. Access would be provided by a drive onto NH 28 opposite Perkins Road. The proposed facility would accommodate approximately 650 parking spaces. Future access to the rail line (assuming it is located on the old abandoned rail corridor) would be direct.

A second park and ride concept, Option 2, is located in the southwest quadrant of the I-93 Exit 5 interchange approximately 0.25 miles south of Exit 5 and parallel to the SB barrel of I-93. This concept is shown in Figure 3.5-5. The land needed to develop this facility would include approximately twenty acres from four private residential properties. Access would be provided via a 1000-foot connector road from Perkins Road, south of the new hotel. The proposed facility would accommodate approximately 700 parking spaces. A pedestrian bridge will be required to access the future rail station platform in the median, similar to what would be required at Exits 2 and 4.

Concord Trailways, in cooperation with the Department, is looking at opportunities to provide bus services at Exit 5.

3.6 Methodology for Projecting Ridership for Rail, Bus and HOV Modes

The main inputs used to forecast ridership for the rail, bus, and HOV options were the 1990 Journey to Work (JTW) data, population and employment forecasts, existing and future travel times, transit travel time, and auto and transit costs. Initial projections were developed for each mode assuming no other modes were provided.

3.6.1 Rail and Bus Ridership Methodology

The method used to project rail and bus ridership is described in the National Cooperative Highway Research Program (NCHRP) Report 187: Quick-Response Urban Travel Estimation Techniques and Transferable Parameters. This or similar methods have been used for planning transit projects by public agencies nationwide. The process for projecting 2020 ridership for each rail and bus option is as follows:

1. The market or service area for each rail or bus station was identified by deciding which towns or portions of towns could reasonably access each station. The future roadway system, travel time and distances were considered. The market areas for the various bus and rail options are shown in Figures 3.6-1 through 3.6-8. Two figures each are presented for the Enhanced Rail and Enhanced Bus services. One figure shows the market for Boston bound commuters, while the second figure shows the market area for commuters to the I-93 employment centers in northern Massachusetts.

2. The 2020 commuter population for each market/service area was based on the trip patterns from the 1990 JTW. These trips were factored based on population growth at the home end and changes in employment at the work end. The resulting number of trips represented 2020 trips from each service area to Boston or the I-93 employment centers.

3. To determine how much of the 2020 commuter population would take transit, the auto and rail impedance's for each origin and destination pair were compared. Transit and automobile travel impedance's were measured in minutes and included total travel time associated with each trip and out-of-pocket costs converted to time (minutes) based on a rate of $25 per hour. The following describes what times and costs were included in the calculations of both auto and transit impedance's.

   ➢ The auto impedance includes:

a) Travel time from home to work place
b) Incremental cost of driving (at $.20 per mile)
c) Average cost per day for parking ($5.00 in downtown Boston).

- The transit impedance includes:

a) Drive time to station
b) Waiting time at station based on drive access time to station with a minimum wait time of 5 minutes.
c) Transfer time at Lawrence and Woburn Transportation Center commuter rail stations (5 minutes)
d) Rail or bus travel time based on service plan
e) Average travel time from rail or bus terminal to final work destination (15 minutes)
f) Incremental cost of driving to station (at $.20 per mile)
g) Auto preference factor to account for general preference for auto use versus transit use (5 minutes)

The transit share was then calculated for each town by using the logit mode choice equation described in the NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters." The mode share calculated from the model was applied to the projected origins and destinations for work trips to develop the projections of travel by rail or bus.

The mode choice equation was used to estimate ridership for the existing bus service in the I-93 corridor. The calculated ridership was then compared to actual boardings at the downtown Manchester Station and the park and ride counts at the Londonderry (Exit 4) stop. In order to match the model results with the actual boardings, adjustments were made to the average hourly wage, the vehicle cost per mile, and the minimum transit wait time. An auto preference factor was added to reflect the preference of rural and suburban commuters for auto travel compared to transit use. Table 3.6-1 illustrates the resulting model calibration by comparing actual 1999 bus ridership with 1999 ridership estimated by the model.

Table 3.6-1
1999 Ridership and Model Estimate for Existing Bus Service

Station	1999 Ridership	Model Estimate[2]
Downtown Manchester	216	237
Exit 4	406[1]	519
Total	632	757

1 Parking lot occupancy count. Number of daily boardings is expected to be higher than parking lot occupancy count because of bus passengers being dropped off. Actual number of boardings was not available.
2 Model results were calculated using the equation described in NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters".

3.6.2 HOV Ridership Methodology

The physical configuration of the HOV facility did not factor into the projections of ridership. The analysis methodology assumed that there would be sufficient enforcement of restrictions on lane use that would keep the HOV lane free flowing until HOV volume reached the capacity of the HOV lane. All non-HOVs were restricted to using the available general purpose lanes and the travel time in the general purpose lanes was estimated based on projected levels of service.

The following presents the steps used to project 2020 utilization of the HOV lane for the HOV options described above. The analysis was conducted for southbound travel in the morning peak period and northbound travel in the evening peak period.

1. Extract 1990 Journey-to-Work (JTW) data for people who would potentially use the HOV lane for a capture area that was assumed to include all towns along the I-93 corridor between the Massachusetts State Line and the Lakes Region as well as towns along the I-89 corridor between Concord, New Hampshire and the Vermont state line.

2. Project 2020 commuter population by using 2020 population forecasts at origin locations and 2020 employment forecasts for work destinations.

3. Develop single occupancy vehicle (SOV) and HOV trip tables.

4. Convert the HOV person trip table to an HOV vehicle trip table using vehicle occupancy rates from the 1990 JTW data.

5. Assign HOVs and SOVs to each link of I-93 in New Hampshire.

6. Calculate SOV travel times for 2020 based on number of general purpose lanes, projected traffic volumes and a speed/volume relationship developed for existing conditions.

7. Develop HOV travel times for 2020 assuming HOV travel time to be 15 mph faster than the SOV travel time with a maximum speed of 65 mph.

8. Develop a matrix showing the HOV travel time savings between origin and destination pairs.

9. Convert the daily HOV volume to a peak two hour volume.

10. Increase the number of HOVs in the peak period based on travel time savings assuming an HOV lane on I-93 in Massachusetts between the New Hampshire state line and I-95 (Route 128).

11. Calculate a peak one hour volume based on 55 percent of peak period vehicles traveling in the peak hour.

12. Reduce the original SOV trip table to reflect diversion to HOV trips.

13. Assign the resulting SOV and HOV trip tables to each link on I-93 in New Hampshire.

Future speeds and travel times were based on the relationship between projected traffic volumes and roadway capacity. Travel speeds in Massachusetts assume that there are four travel lanes in each direction because of the peak period shoulder lane use between the current lane drop north of Route 125 and the Pelham Street exit. The future travel time is also based on the assumption that the Central Artery Project is complete with the number of lanes approaching downtown Boston across the Charles River increased.

3.7 Ridership Projections

The preliminary ridership projections for the individual rail, bus, and HOV modes were based on the following assumptions:

- There are four lanes in each direction on I-93 between the I-293 split and the Massachusetts state line,

- In Massachusetts, the shoulder lane is open to traffic during peak periods between the Route 125 and Pelham Road interchanges,

- The Central Artery Project in Boston is complete, and

- The Lowell commuter rail line is extended to Nashua from Lowell, Massachusetts.

3.7.1 Rail

Table 3.7-1 summarizes the total ridership for each rail alternative. Tables showing boardings for each route and station are included in the appendix to the ridership documentation report. The West Rail Corridor boardings include only the Merrimack, Bedford and Manchester stations, as the proposed extension to Nashua from Lowell is considered part of the No-Build condition.

Table 3.7-1
Total Boardings by Rail Corridor

Rail Corridor	Daily Boardings
West Corridor	428*
East Corridor	957
I-93 Basic	900
I-93 Enhanced (Boston passengers only)	1,160
I-93 Enhanced Rail (all passengers)	1,811

* Includes only passengers boarding at Downtown Manchester, Bedford/Manchester Airport and Merrimack

The West Rail Corridor generated the smallest ridership of the four rail options with 428 daily boardings. The East and I-93 Basic Rail Corridors generated more than twice as many daily boardings than the West Rail Corridor with 957 and 900 boardings, respectively. These two corridors generate essentially the same ridership because they are parallel and close to each other, serve the same market areas, and provide similar service. As a result, it was decided not to use the I-93 Basic Rail Corridor in any subsequent analyses. The Enhanced Rail Corridor generated the largest Boston bound ridership with 1,160 boardings. In addition, it included about 650 boardings for commuters destined to I-93 employment centers in Massachusetts resulting in a total of over 1,800 boardings.

3.7.2 Bus

Table 3.7-2 summarizes the ridership projections for the expanded bus option with and without various HOV lane options and with and without a fare subsidy. Tables showing boardings by route and bus stop are included in the appendix to the ridership documentation report. Daily bus inbound boardings with no HOV lane and no subsidy are projected to be about 1,280. This number remains virtually unchanged with the addition of an HOV lane in New Hampshire only, but increases by 660 with the addition of an HOV lane in New Hampshire and Massachusetts. The addition of a bus subsidy increases daily inbound boardings by 250 to 270 riders.

Table 3.7-2
Total Daily Bus Boardings for each Alternative

Station	No HOV Lane	With NH HOV Lane	With NH/MA HOV Lane
Expanded Bus with No Fare Subsidy	1,281	1,292	1,941
Expanded Bus with Fare Subsidy	1,531	1,543	2,212

3.7.3 HOV Lanes

Table 3.7-3 presents the HOV ridership projections with no HOV lane in Massachusetts and Table 3.7-4 presents ridership projections with an HOV lane in both New Hampshire and Massachusetts. The tables present projected HOV volumes for each segment of the I-93 corridor. They include the daily inbound HOV volumes expected whether or not there is an HOV lane, the increase in HOVs expected with an HOV lane, and the resulting inbound peak hour HOV volumes.

Table 3.7-3
HOV Projection – with New Hampshire HOV Lane

I-93 Segment	Daily HOVs without HOV Lane	Daily HOVs with HOV Lane	Increase in HOVs with HOV Lane	Peak Hour HOVs
I-293 to Exit 5	794	794	0	192
Exit 5 to 4	1,256	1,256	0	304
Exit 4 to 3	1,735	1,735	0	420
Exit 3 to 2	1,908	1,908	0	462
Exit 2 to 1	2,059	2,059	0	498
Exit 1 to state line	2,506	2,506	0	606

As shown in Table 3.7-3, there will not be sufficient travel time savings to induce the formation of new carpools or vanpools with an HOV lane in New Hampshire only. With the introduction of an HOV lane in both New Hampshire and Massachusetts, daily inbound HOV volumes are projected to increase by between 100 north of Exit 5 and over 400 south of Exit 1. For this analysis, the projected HOV volumes include only work trips. No estimate was made of non-work trips.

Table 3.7-4
HOV Projection – with New Hampshire and Massachusetts HOV Lane

I-93 Segment	Daily HOVs without HOV Lane	Daily HOVs with HOV Lane	Increase in HOVs with HOV Lane	Peak Hour HOVs
I-293 to Exit 5	794	889	95	215
Exit 5 to 4	1,256	1,440	184	349
Exit 4 to 3	1,735	2,010	274	486
Exit 3 to 2	1,908	2,224	316	538
Exit 2 to 1	2,059	2,396	337	580
Exit 1 to state line	2,506	2,927	421	708

3.7.4 Sensitivity Analysis

A sensitivity analysis was conducted to determine how total ridership on the East Rail Corridor varies when model assumptions are modified. The sensitivity analysis included variations in highway configuration assuming 2, 3 or 4 general purpose lanes in each direction on I-93 in New Hampshire along with the following:

- Varying the parking cost in Boston from $5 per day to $10 and $15 per day
- Changing the value of time (average wage rate) from $25 per hour to $20 per hour
- Increasing the marginal operating cost for automobiles from $0.20 per mile to $0.25 per mile
- Increasing the minimum transit wait from 5 minutes to 10 minutes
- Removing the transfer time at Lawrence Station (to model direct service to Boston)

Table 3.7-5 summarizes the results of the sensitivity analysis. The first column indicates the number of general purpose highway lanes and the second column presents the base ridership projection with the unmodified model assumptions. The remaining columns present the revised ridership projection for each change in the model assumptions.

Table 3.7-5
Total Ridership for Sensitivity Analysis

Number of Lanes	Base Case	$10 Parking Cost	$15 Parking Cost	Value of time @ $20/hr	$0.25 per mile	10 min Wait Time	No Transfer Time
2	1,253	1,833	2,366				
3	1,038	1,629	2,199				
4	957	1,543	2,126	1,258	1,199	777	1,169

An increase in parking costs increases ridership substantially. Increased parking costs increase total auto cost causing the East Rail Corridor to be relatively less expensive than driving, resulting in an increase in rail ridership. A five dollar increase in parking cost results in an increase of 500 to 600 daily inbound boardings out of a base case of about 1,250 boardings.

A decrease in the value of time and an increase in the cost per mile both result in an increase in the cost of auto travel relative to the cost of transit. Transit boardings increase by about 300 with a decrease in value of time and by about 240 with an increase in cost per mile of operating an automobile. The value of time and the cost per mile affect the auto mode more than the transit mode because out of pocket cost for automobiles is a greater portion of the mode’s impedance.

Increasing the minimum transit wait time to 10 minutes results in transit being more expensive relative to the auto mode and therefore total ridership decreases by 180 daily inbound boardings. Finally, the elimination of a transfer time increases daily inbound boardings by more than 210 because transit becomes less expensive relative to the auto mode.

3.8 Summary

The preliminary analysis of the eight mode options presented provided an understanding of the potential of each and a focus for further development of individual mode options as well as development of combinations of mode options. The analysis indicated that ridership volumes for the I-93 Basic Rail option would be similar to that for the East Rail option, and consequently subsequent analyses do not test the Basic Rail option. Similarly, the New Hampshire-only HOV lane does not produce sufficient ridership on busses or in carpools to warrant further testing of this option.

As discussed in Chapter 5, additional studies were conducted to evaluate the mode options in combination with each other and with various highway widening schemes, to both test the ridership that might be generated as well as to project the resulting level of service of the highway given the ridership generated.

4

Development of Highway Alternatives

4.1 Introduction

This chapter describes highway alternatives developed for the I-93 corridor. Alternatives include the No Build condition as a base comparison, Transportation System Management (TSM) options to accommodate interim improvements at selected locations, and various highway widening alternatives from the existing two lanes in each direction to either three and/or four lanes in each direction. Possible design improvements to existing interchange configurations and connecting roads within the study area will also be discussed. The criteria used for developing existing and proposed traffic volumes is also presented in the following sections.

4.2 Traffic Criteria

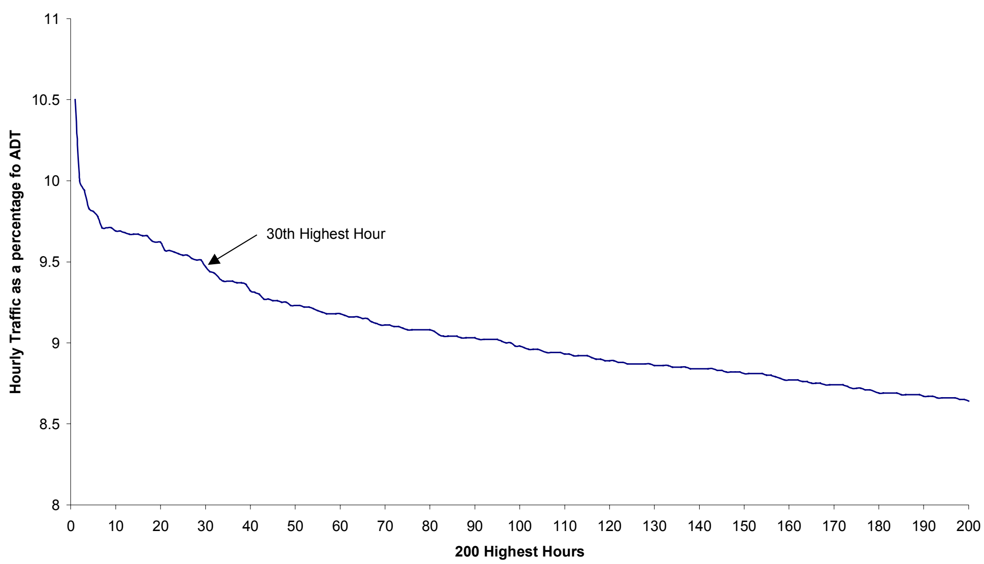
The first step in evaluating the previously described alternatives is to establish an appropriate traffic volume condition. The volume of traffic along the corridor varies widely depending on the hour of the day, the day of the week, and the week of the year. Establishing an appropriate design volume condition is critical to the evaluation process. The purpose of this section is to present the traffic evaluation criteria that was used to evaluate the alternatives. The section includes a discussion on Design Hour Volume, Level of Service, and Basic Lane Requirements.

4.2.1 Design Hour Volume

The unit of measure used to evaluate and design roadway facilities is an hourly traffic volume or vehicles per hour (vph). However, because hourly traffic volumes can vary over the course of a day and throughout the year, it is necessary to select an appropriate design hourly volume condition. It would be wasteful to predicate a design on the (maximum) peak hour traffic of the year, yet the use of the average hourly traffic would result in an inadequate design. The hourly traffic volume used for the purpose of design should not be exceeded very often or by very much. On the other hand, it should not be so high that the volume of traffic would rarely be high enough to make full use of the facility.

The procedure used to evaluate traffic volume demands on a roadway system, as described in *A Policy on Geometric Design of Highways and Streets*[8], is to establish a 30th highest hour volume (design condition). Given the economic considerations involved in the planning and design of roadway facilities, this design criteria is selected since the 30th highest hourly volume generally reflects a "point of diminishing return" in that a substantial increase in design requirements would accommodate only very few periods of higher traffic volumes. This condition is reflected in the curve, as shown in **Figure 4.2-1**, which tends to steepen quickly to the left of the 30th highest hour indicating much higher volumes for the inclusion of only a few more of the higher hourly volumes while the curve flattens to the right indicating many hours in which the volume is not much lower than the 30th highest hour.

Figure 4.2-1
Peak Hour to ADT Relationship
I-93 At Fordway Bridge In Derry (1997)



Based on the data provided at the NHDOT permanent count station located on I-93 in Derry, the 30th highest hour volume is approximately 9.4 percent of the ADT. The Directional Design Hour Volume (DDHV) split shows approximately 60 percent of the total hourly traffic traveling in the peak direction.

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[8] American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, Washing, D.C.

4.2.2 Level of Service

Level of service is a qualitative measure use to describe the operational conditions within a traffic stream and the perception of the quality of traffic flow by a motorist or passenger. Level of service (LOS) generally describes these conditions in terms of such factors as speed and travel time, density or freedom to maneuver, traffic interruptions, comfort and convenience, and safety and, in so doing, provides an index to quality of traffic flow. Six levels of service are defined[9] ranging in letter designation from LOS A to LOS F, with LOS A representing the best operating condition and LOS F representing the worst. LOS C describes a stable flow condition and is considered desirable for peak or design hour traffic flow. LOS D is generally considered acceptable where the cost and impacts of making improvements to provide LOS C are deemed unjustifiable. Level of Service E is capacity. The traffic performance measures and the evaluation criteria used in the operational analyses are based on the methodology presented in the 1994 Highway Capacity Manual[10].

For the purpose of the design of new roadway facilities, the New Hampshire Department of Transportation (NHDOT) has established LOS C as desirable and LOS D as minimally acceptable. However, despite establishing LOS D as the minimally acceptable level of service, the NHDOT has also expressed a general policy of not constructing highways with more than eight basic lanes (four lanes in each direction)[11]. Therefore, for the purpose of this evaluation, the goal will be to provide at least a LOS D operation in the year 2020 while constructing no more than four basic lanes in each direction.

4.2.3 Basic Lane Criteria

The basic lanes of a highway are the travel lanes along a facility that are needed solely to accommodate the movement of through traffic. Basic travel lanes do not include traffic management lanes such as climbing lanes, acceleration/deceleration, weaving, and merging type lanes, which may be needed in the vicinity of an interchange to accommodate vehicles entering and exiting the highway. These basic lanes serve to provide a consistent number of lanes over a significant length of highway.

To determine the number of basic lanes that will be needed to accommodate traffic flow along each segment of the I-93 study corridor, it was necessary to apply the level of service criteria to the future year design hour traffic volumes. Therefore, each segment of the corridor was evaluated to determine the number of basic lanes that

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[9] ibid

[3] 1994 Highway Capacity Manual, Special Report 209, Transportation Research Board, Washington, D.C.

[11] Consideration of more than 8 lanes would only be given if Massachusetts were to propose a widening that involved more than 8 lanes.

would be needed to provide at least a LOS D operation during the design hour (30^{th} highest volume) in the year 2020.

In determining the basic lane requirements, it is important to recognize that the 2020 traffic volume projections for this project are conservative (i.e. relatively low). The traffic model is projecting traffic volume growth rates for the corridor of between 1.0 and 1.5 percent per year. By comparison, as presented in the previously published Scoping Report, daily traffic volumes along the corridor for the most recent 20 year period (1980-2000) have been growing at an average annual rate of approximately 5.1 percent. Therefore, the basic lane requirements presented in this section should be considered the minimal lane requirements.

The projected 2020 ADT, DHV and - most importantly for determining the number lanes needed - DDHV for each segment of the corridor are shown in Table 4.2-1. As shown in the table, the projected 2020 DDHV ranges from a low of 4,100 vehicles per hour (vph) between Exits 3 and 4 to a high of 7,700 vph south of Exit 1.

Table 4.2-1
2020 Average Weekday and Design Hour Volumes (No Build)

Segment	ADT[1]	DHV[2]	DDHV[3]
North of Exit 5	84,300	7,900	4,800
Between Exits 4 and 5	81,200	7,600	4,600
Between Exits 3 and 4	73,000	6,900	4,100
Between Exits 2 and 3	98,000	9,200	5,500
Between Exits 1 and 2	103,600	9,700	5,800
South of Exit 1	137,000	12,900	7,700

[1] ADT – Average Daily Traffic
[2] DHV - Design Hour Volume
[3] DDHV - Directional Design Hour Volume

The results of the operational analyses indicate that to provide at least a LOS D operation in 2020 would require the following number of basic lanes along the corridor.

- 10 lanes (5 lanes in each direction) south of Exit 1,
- 8 lanes (4 lanes in each direction) between Exit 1 and Exit 3, and
- 6 lanes (3 lanes in each direction) between Exit 3 and I-293.

Again, the basic lane requirements are the number of basic lanes, exclusive of traffic management lanes, that are needed to accommodate through traffic along the each segment of the I-93 corridor. Note that to provide an LOS D operation along the segment south of Exit 1 would require a ten-lane section. This exceeds the NHDOT's general policy of not constructing highways with more than eight basic lanes (four lanes in each direction).

Also note that the basic lane requirements were determined prior to considering any potential reduction in the volume of traffic that would occur as a result of the implementation of travel demand management (TDM) measures such as rail, transit, and high occupancy lanes (HOV), etc. An evaluation of these other modes of transportation and their affect on the corridor lane requirements is provided in Chapter 5.

4.3 No Build

The No Build Alternative is essentially the continuation and perpetuation of the existing situation and the shortcomings inherent on the present highway corridor. The No Build Alternative will serve as a baseline condition for comparison with other alternatives. This section includes a discussion on the Statewide Travel Demand Model, which was used to develop the future traffic volume projections, and a discussion on the concept of induced travel as it relates to the potential influence that adding capacity to a highway induced motorists to utilize the highway.

4.3.1 Traffic Model

As described in the Scoping Report, in 1994 the NHDOT began an important statewide study to carry the Department's transportation planning into the 21st century. The overall goal of the Statewide Planning Study is to "provide recommendations for developing a coordinated transportation system that will facilitate the movement of persons and goods in a safe, cost-effective, efficient, and environmentally conscious manner." Recommendations from this study were to be directed to all transportation modes in the State of New Hampshire, including highways and public transportation.

The New Hampshire Statewide Travel Demand Model System (NHSTMS) was developed as part of this study. The model helps predict travel behavior (i.e., how people travel- by car, bus, etc.) and travel demand (i.e., how many people want to travel on a certain road or by a certain mode). The model is based on statewide data collected on highway, bus, and rail systems, and on land use, and social and economic characteristics. Household travel, roadside motorist, and transit rider surveys were conducted as part of the data collection effort in 1994. The model is intended to identify potential new or improved transportation services and strategies, in an effort to improve overall transportation services, reduce congestion and improve air quality.

The NHSTMS is a tour-based model system consisting of many sub-models, or components. The system is intended to model travel by auto and transit modes for a summer weekday. The base year of the model is 1990 with analysis capabilities for all forecast years ranging from 1997 to 2020, although years beyond 2020 could be analyzed using extrapolation of socio-economic forecasts.

The I-93 sub-area is one of the sub-models or components of the Statewide model. The I-93 sub-area model is more detailed, that is, it has smaller and consequently more traffic zones and somewhat finer highway networks than the Statewide model. The zones and the highway network for the I-93 sub-area model were developed in consultation with the appropriate regional planning commissions (RPCs), local officials and others. The zones and the network for the I-93 sub-area model are consistent with the Statewide overlapping regional models. All links in the Statewide transportation network which are located in the I-93 sub-area are included in the model. The zones are subsets of the Statewide model zones and consistent with the zones in overlapping regional models.

The trip tables for the I-93 sub-area model were developed from the Statewide model. These trip tables were imported into the sub-area model and then traffic assignments were made for the sub-area. The 1997 base year sub-area model was considered to be calibrated when the traffic assignments reasonably reflected the traffic volumes estimates made by the NHDOT on I-93 from the State line to the I-93 and I-293 split in Manchester.

Based on the guidelines published in the Federal Highway Administration's Report *Calibration and Adjustment of System Models*[12], the 1997 sub-area model traffic assignments fell within the acceptable range of accuracy for freeways. Similarly, the sub-area model assignments for other major roadways such as NH 28, NH 111, and NH 102 were also compared to actual 1997 data and were determined to be within the acceptable range of accuracy for these types of facilities. Therefore, with the model calibrated, it was determined that the 1997 sub-area model accurately reflects the actual traffic volume conditions within the project area and could be used for planning and forecasting purposes.

Traffic forecasts were made for year 2020 for the I-93 sub-area using the model. The 2020 highway network includes proposed improvements (expected to be completed by 2020) such as the I-293 widening, the Manchester Airport Access Road, the Nashua Circumferential Highway, and the F.E. Everett Turnpike (FEET) expansion. Traffic forecasts from the I-93 subarea model were compared with traffic forecasts for 2020 from the Southern New Hampshire Planning Commission model, the Manchester Airport Access Model, the Windham-Salem NH 111 model, and the Nashua Regional Planning Commission model, and correlations were found to be acceptable.

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[12] Calibration and Adjustment of System Models, Federal Highway Administration, December 1990.

4.3.2 Induced Travel

Induced travel is a relatively new term that generally refers to any increase in travel that results solely from increasing the capacity of the transportation system. That is induced travel is not an increase due to demographic changes in population, income levels, or markets. As such induced travel is the result of increases in residential, commercial, and/or industrial development; increases in the number of trips between developments; increases in automobile travel at the expense of transit travel; and increases in travel in one corridor at the expense of another corridor.

Intuitively, the concept of induced travel makes sense. It is based on the economic principle of supply and demand. If you increase the capacity of the highway (the supply) you would in turn reduce the travel time or the cost of travel. Any reduction in the cost of travel would, in theory, result in an increase in the demand for travel. The magnitude of the change is represented by the elasticity of travel with respect to a change in travel time. However, determining what elasticity is appropriate for any specific case is not easy to do given the numerous other factors that lead to increased travel such as demographic changes, technological advances, cultural biases, etc. To quantify the level of induced travel, one must isolate the induced travel portion of the travel increase from the increase in travel that results from these other factors.

Research on the subject of induced travel is still in its infancy stage and there are no widely accepted standards for quantifying the impacts of induced travel. One relatively simple approach (as proposed in a research paper by the US Environmental Protection Agency (EPA) and the Centre for Transport Studies, Imperial College, London, England) is to assume that for every 10% increase in capacity induced travel would result in an additional 2.9% increase in traffic over and above that predicted through more traditional projection techniques. This approach does not take into account the current capacity of the facility or the projected level of service, the constraints elsewhere on the system or the region served. With this approach, increasing the capacity by adding one additional lane in each direction (a 50% increase) would result in traffic volumes 15% higher than predicted. Increasing the capacity by adding two lanes (a 100% increase) would result in traffic volumes nearly 30% higher.

For its part, the Federal Highway Administration (FHWA) has developed a "Spreadsheet Model for Induced Travel Estimation" (SMITE) that can be used at a sketch planning level to estimate the potential effects of induced travel. The SMITE spreadsheet is based primarily on two input variables. The variables are the elasticity of travel demand and the ratio of freeway traffic to arterial traffic. Because much of the current debate and ongoing research is focused on quantifying the level of elasticity, it should be recognized that any result obtained from the spreadsheet is only as good as the input elasticity. Similarly, the ratio of freeway traffic to arterial traffic is somewhat subjective as the limits of the influence area can vary widely.

Nevertheless, a number of trials were conducted using various combinations of input data in an effort to determine a range of potential induced travel estimates for the I-93 corridor. Two technical memoranda, which discuss the concept of induced travel in greater detail and include the backup calculation from the SMITE spreadsheet, are provided in the Appendix of the report.

The results of the trial runs revealed the potential increase in vehicle miles traveled (VMT) for the overall study area (freeway and arterials) could range from 2 to 8 percent. The increase in VMT on the freeway (I-93) varied widely – ranging from 17 to 41 percent.

While the phenomenon of induced travel is worthy of further study from a general transportation perspective, and something for decision makers in New Hampshire to be aware of, estimating its magnitude and including such estimates in the analysis of traffic is not recommended. In reviewing existing literature and studies, a consensus of understanding has not been reached on the issue and a confirmed methodology for estimating its affects is not available. The Statewide Travel Demand Model accounts for some of the elements of induced travel and should continue to be the basis for analyzing traffic related issues.

4.4 Highway Widening / Geometric Improvements

Given the major capital investment in the existing I-93 corridor, all design concepts have focused on widening the existing roadway rather than constructing a new facility off line. The concepts presented in this section were developed using the design criteria identified in the Scoping Report and following NHDOT design standards for an interstate facility. In addition, environmental, socio-economic and engineering constraints were taken into account to try and minimize impacts to resources whenever practicable. Proposed mainline and interchange improvement concepts have been separated out for discussion purposes and are presented in the following sections.

4.4.1 I-93 Mainline Improvement Concepts

Conceptual improvements to the I-93 mainline were developed based on a typical roadway cross section which included four 12 ft. travel lanes, a 10 ft. outside shoulder, a 14 ft. inside (HOV enforcement) shoulder and a 4 ft. painted buffer area between the two inner most travel lanes, in each direction. The inner most travel lane could be utilized as an HOV lane. As mentioned, this typical cross section would be mirrored in the opposite direction for a total of 8 lanes or 4 lanes in each direction. The minimum median width between the two NB and SB barrels would vary between approximately 60 ft. to 90 ft. so as not to preclude the potential for a future rail line down the median.

In considering what the future might hold for the I-93 corridor and for transportation in general in the State of New Hampshire, the NHDOT anticipates that transportation modes involving rail or busways will need to play a role in New Hampshire's transportation's future, if New Hampshire is to maintain the mobility currently available. With that in mind, and given the difficulties associated with reactivating rail along the abandoned Manchester and Lawrence Line (M&L), the NHDOT has proposed to reserve space for a possible future passenger rail line within the I-93 highway corridor. The NHDOT feels that it is in the best interest of the State to layout a right-of-way that will not only provide for the highway, but allow for opportunities for bus service, as well as, rail and other amenities.

The rail layouts within the I-93 rail corridor as discussed in section 3.3.3 of this report, would accommodate two tracks and have four rail stations (Exits 2, 3, 4 and 5) within the I-93 corridor in New Hampshire. The rail line would provide passenger service only, using light rail vehicles capable of traversing the grades and curves associated with the I-93 corridor. The train would travel in the median to greatly minimize impacts to private property and environmental resources, and to minimize infrastructure costs otherwise needed to bridge over interchange ramps and local roadways. Train stations at Exits 2, 4, and possibly 5, would be located adjacent to park and ride lots proposed as part of the highway widening. Train passengers would access the train via a pedestrian bridge crossing over the NB or SB highway barrels, to a rail platform in the median, between the two tracks. At Exit 3 and possibly Exit 5, direct access from the station to the rail platform is possible and may not require a pedestrian bridge. At Exit 5, the rail line has three potential alignments (see Figure 4.4-27), which will accommodate various speeds and provide for a possible future connection to the Manchester Airport, further to the west. As the rail line approaches Exit 1 from the north, the line crosses over the SB barrel of I-93 to the west of, and around, the Rockingham Boulevard SB ramps and then travels along the west side of the highway. The rail line would then be able to cross over the highway just south of the state line to access the Lawrence Station or continue south along I-93 into Massachusetts to the Woburn Transportation Center.

The typical cross sections are depicted in Figures 4.4-1 and 4.4-2. It should be noted that the typical section is intended to represent the most conservative practicable design expected. As such, implied impacts represent worst case impacts relative to the mainline footprint.

All of the concepts discussed in this section have been presented at the most recent public officials meetings conducted in November and December 2000, in each of the five surrounding communities. The discussion of the mainline improvements will be further broken out by segments so that an appropriate level of detail can be discussed, and issues and constraints can be identified along the corridor.

The mainline segment of I-93 in Salem, between Exits 1 and 2 has three concepts that were evaluated and will be described in more detail in the following sections as Concepts 1, 2 and 3. Although the main difference lies in the segment between Exits 1 and 2, design differences carry through to the Windham-Salem town line.

4.4.1.1 State Line in Salem to Exit 1 – Concept 1

All three of the proposed concepts begin at the state line in Salem and proceed to Exit 1. There are a number of constraints within this area including Policy Brook, the Spicket River, residential development, and the existing Rest Area to the east; wetlands to the west; a narrow median; and the Cross Street overpass and its intersection with Brady Avenue where homes are in close proximity to the existing highway.

The proposed concepts in this area are basically the same and hold the outside edge of the existing NB barrel and widen both barrels to the west. A collector-distributor road is proposed to access the rest area and the NB off-ramp at Exit 1. Since Concept 1 requires construction of a new NB barrel east of the existing NB barrel just north of Exit 1, Concept 1 will involve additional impacts south of Exit 1 due to the added construction required to push the highway and its transitions (i.e., ramp merges and diverges) further to the east just south of Exit 1. This initial concept is depicted in Figures 4.4-3 and 4.4-4. The rail line would be outside of the median and located along the west side of the widened SB barrel. In doing so, the rail line would be able to cross over the highway just south of the state line to access the Lawrence Station or continue south along I-93 into Massachusetts to the Woburn Transportation Center.

4.4.1.2 Between Exit 1 and Exit 2 – Concept 1

As Concept 1 approaches Exit 1 the future rail line would proceed adjacent to, and westerly of, the SB ramps and then cross over the I-93 SB barrel just north of Exit 1 to access the median area. Concept 1 would utilize the existing NB barrel for the future rail line and require construction of a new NB barrel east of the existing. The SB barrel would be widened to the west. Constraints in this area include prime wetlands surrounding the Exit 1 SB ramps and within the median (surrounding and including Porcupine Brook), and along the east and west side of the existing highway between Exits 1 and 2. Residential and industrial buildings also exist in close proximity to the highway along the east side of the NB barrel. This concept is depicted in Figure 4.4-5.

Concept 1 would have no impact to the Porcupine Brook and prime wetland in the highway median, however, prime wetlands along the east side of the existing NB barrel would be impacted as would a portion of prime wetland just west of the SB barrel.

4.4.1.3 From Exit 2 to the Salem/Windham Town Line – Concept 1

As Concept 1 proceeds through Exit 2 the future rail line would remain within the median and the existing outside edge of the NB barrel would be held as a control with the road widened towards the median. The SB barrel would be widened to the west. Retaining walls would likely be investigated to minimize impacts to buildings in close proximity to the widened SB barrel just beyond the NW quadrant of Exit 2. This is depicted in Figures 4.4-6 and 4.4-7.

One major constraint that has been identified in this area is Canobie Lake. The existing NB barrel will be widened towards the median in this area to address water quality issues relating to Canobie Lake, which is the drinking water supply for the Town of Salem.

4.4.1.4 State Line in Salem to Exit 1 – Concept 2

Concept 2, like Concept 1, begins at the state line in Salem and proceeds to Exit 1. The constraints within this area remain the same and include Policy Brook, the Spicket River, the residential development, and the existing Rest Area to the east, wetlands to the west, a narrow existing median, and the Cross Street overpass and its intersection with Brady Avenue, where homes are in close proximity to the existing highway.

Concept 2, again similar to Concept 1 holds the outside edge of the existing NB barrel and widens both barrels to the west. A collector-distributor road is proposed to access the rest area and the NB off-ramp at Exit 1. The only real difference between Concepts 1 and 2 is that for Concept 2 the rail is being located in the median north of Exit 1 (as opposed to on the existing NB barrel) and therefore the encroachment of the NB barrel to the east beginning south of Exit 1 can be minimized. This concept is depicted in Figure 4.4-8.

4.4.1.5 Between Exit 1 and Exit 2 – Concept 2

As Concept 2 approaches Exit 1 the future rail line would continue to proceed adjacent to, and westerly of, the SB ramps and then cross over the I-93 SB barrel just north of Exit 1 to access the median area. Concept 2 would have the NB barrel remain in its existing location and be widened to the east. The SB barrel would be widened to the west. As with Concept 1, constraints in this area are prime wetlands surrounding the Exit 1 SB ramps, within the median area (surrounding and including Porcupine Brook), and along the east and west side of the existing highway between Exits 1 and 2. Residential and industrial buildings also exist in close proximity to the highway along the east side of the NB barrel. This concept would minimize impacts to those structures. This concept is depicted in Figure 4.4-9.

Concept 2 would have minimal impact to Porcupine Brook in the median area if the future rail line were to be built on structure, and, prime wetlands along the east side of the NB barrel would be less impacted as proposed with Concept 1.

4.4.1.6 From Exit 2 to the Salem/Windham Town Line – Concept 2

As Concept 2 proceeds through Exit 2 the proposed rail line would remain within the median similar to Concept 1, with the SB barrel widened to the west. Retaining walls would still likely be investigated to minimize impacts to buildings in close proximity to the widened SB barrel just beyond the NW quadrant of Exit 2. This is depicted in Figure 4.4-10 and essentially matches Concept 1 just north of Brookdale Road.

As with Concept 1, one major constraint that has been identified in this area is Canobie Lake. The existing NB barrel will be widened towards the median in this area to address water quality issues relating to Canobie Lake, which is the drinking water supply for the Town of Salem.

4.4.1.7 State Line in Salem to Exit 1 – Concept 3

Like Concepts 1 and 2, Concept 3 begins at the state line in Salem and proceeds to Exit 1. The constraints within this area remain the same and include Policy Brook, the Spicket River, residential development and the existing Rest Area to the east; wetlands to the west; a narrow existing median, and the Cross Street overpass and its intersection with Brady Avenue where homes are in close proximity to the existing highway. The Concept is depicted in Figure 4.4-11.

Again similar to Concepts 1 and 2, Concept 3 holds the outside edge of the existing NB barrel and widens both barrels to the west. A collector-distributor road is proposed to access the rest area and the NB off-ramp at Exit 1. The main difference with Concept 3 is that the rail is now remaining to the west through Exits 1 and 2. In doing so, the encroachment of the NB barrel to the east beginning south of Exit 1 can be minimized, similar to the layout proposed with Concept 2.

4.4.1.8 Between Exit 1 and Exit 2 – Concept 3

As Concept 3 approaches Exit 1 the future rail line will continue to proceed adjacent to, and westerly of, the SB on- ramps. The rail line does not cross over the I-93 SB barrel, but instead remains along the west side of the existing SB barrel. Concept 3 would continue this western layout through Exit 2. The NB barrel would remain in its existing location and be widened to the east. The SB barrel would be widened to the west. As with Concepts 1 and 2, constraints in this area are prime wetlands surrounding the Exit 1 SB ramps, within the median area (surrounding and including Porcupine Brook), and along the east and west side of the existing highways between Exits 1 and 2. Residential and industrial buildings also exist in close proximity to the highway along the east side of the NB barrel. This concept would minimize impacts to those structures. However structures to the west, along Fern Road and NH 38 would have increased impacts as a result of this concept. This concept is depicted in Figure 4.4-12.

Concept 3 would have minimal impact to Porcupine Brook in the median area, and prime wetlands along the east side of the NB barrel would not be heavily impacted, however, prime wetlands along the west side would be less impacted as proposed with Concept 1. North of Exit 2 the rail line still does not have enough of an angle to cross over the SB barrel and into the median area until just north of the Salem/Windham town line where the NB and SB barrels diverge. This concept appears to have greater impacts on wetlands and property than the other two concepts.

4.4.1.9 From Exit 2 to the Salem/Windham Town Line – Concept 3

As Concept 3 proceeds through Exit 2 the future rail line would remain along the west side of the I-93 corridor until reaching the Windham-Salem town line. At this point, the rail curves to the west before curving back across the existing SB barrel and tying into the rail layouts proposed with Concepts 1 and 2 just beyond Wildwood Road. Retaining walls would be investigated to minimize impacts to buildings in close proximity to the rail just north of the Exit 2 SB ramps. This concept is depicted in Figures 4.4-13 and 4.4-14.

As with Concepts 1 and 2, one major constraint that has been identified in this area is Canobie Lake. The existing NB barrel will be widened towards the median in this area to address water quality issues relating to Canobie Lake, which is the drinking water supply for the Town of Salem. Additional land will be impacted as a result of the rail's departure from the existing I-93 corridor just north of the Salem/Windham town line.

4.4.1.10 From the Salem/Windham Town Line to Exit 3

All remaining mainline improvement concepts reflect essentially just one mainline improvement for each of the remaining segments. Minor variations will be evaluated as appropriate to resolve what the preferred layout should be given the resources involved and the degree of impact.

The area south of Exit 3 provides a very wide median area (up to 1200 ft. wide), which allows the existing highway to be widened and the alignments to be adjusted towards the median for both the NB and SB barrels. The rail is proposed to run adjacent to the NB barrel. This segment of I-93 is constrained by Canobie Lake to the east, Cobbetts Pond to the west, and a number of wetlands both inside and outside of the median. Widening and adjusting alignments towards the median in this area will help minimize water quality impacts relative to Canobie Lake, which is the drinking water supply for the Town of Salem, and Cobbetts Pond, an important recreational resource in Windham.

Other constraints include neighborhoods along South Shore Road, Wildwood Road and Robin Hood Road to the east, Locust Road to the west, and NH 111A passing through the median, all in close proximity to the highway.

Just north of the NH 111A overpass the concept shown in Figure 4.4-15 depicts a relocation of the NB lane to approximately half-way in between the existing NB and SB barrels. This relocation will improve the existing vertical and horizontal highway geometry and will accommodate shifting the existing NB ramps/NH 111 intersection further away from the NH 111/NH 111A intersection to improve the operations of these two intersections and the whole interchange area. An added benefit is the increased distance between the NB barrel and Canobie Lake and the simplified construction in terms of maintenance of traffic.

4.4.1.11 From Exit 3 to the Weigh Station

As the corridor passes through the Exit 3 area, the NB and SB barrels converge for a short distance down to a median width of approximately 150 ft. wide before diverging once again to a more consistent average median width of 300 ft. approaching the weigh stations. This allows for widening the existing highway towards the median for both the NB and SB barrels and avoid impacts to the recently reconstructed weigh stations, as well as residential, industrial, and historic properties. This segment is depicted in Figures 4.4-16 & 4.4-17.

This segment is constrained by wetlands both inside and outside of the median. Wetlands along the SB barrel serve as a heron rookery. Also, adjacent to the SB weigh station is the Golden Brook Headwaters, which could be a concern from a water quality standpoint.

4.4.1.12 From the Weigh Station to the Windham/Derry Town Line

Continuing north from the weigh stations, the NB and SB barrels converge to a fairly consistent average median width of 100 ft. The vertical profiles for the two barrels are at the same elevation at the weigh stations and at North Lowell Road, but differ by as much as 16 feet as the two barrels converge and diverge through this area. This segment is constrained by various wetlands outside of the median. Also, west of the SB barrel is the Bridge Street Pond, which could be a concern from a water quality standpoint. An additional engineering constraint comes into play with North Lowell Road as there are economic benefits to matching these existing bridges as opposed to replacing the bridges. This segment is depicted in Figures 4.4-17 and 4.4-18.

With these constraints in mind, the proposed concept shows a minimum 60 ft. rail corridor width through this segment, complimented by retaining walls as needed, with widening for both the NB and SB barrels weaving back and forth between widening to the inside and the outside to minimize impacts, while trying to provide a workable engineering solution.

4.4.1.13 From the Windham/Derry Town Line to Kendall Pond Road

Proceeding north from the Windham/Derry town line, the NB and SB barrels maintain a fairly consistent cross-section through this segment. This segment is constrained by various sized wetlands mainly outside of the median, including a large prime wetland area just south of Fordway Extension, which will also be a concern from a water quality standpoint. Additional engineering constraints exist within this segment and include the recently reconstructed bridges at Fordway and Kendall Pond Road; the ledge surrounding both the NB and SB barrels, including within the median area; and the 20 feet of grade differential of the NB and SB barrels. The neighborhood along Derryfield Road provides additional reasons for widening the NB lanes towards the median in this location. This concept is depicted in Figures 4.4-19 and 4.4-20.

The concept as shown utilizes a minimum 60 ft. rail corridor width through most of this segment and assumes retaining walls will be required to support the highway and rail infrastructure. Widening for the NB barrel will be accomplished by holding the eastern or outside existing edge as a control and widening towards the median. Widening for the SB barrel as shown assumes holding the eastern or inside existing edge as a control and widening to the west. This layout for the SB barrel will be investigated in more detail with consideration of reducing the retaining wall construction and addressing traffic control during construction.

4.4.1.14 From Kendall Pond Road to Ash Street

Just north of Kendall Pond Road, and east of I-93, is a sewage treatment facility. A large wetland area is located between the sewage treatment facility and the highway. This wetland also runs adjacent to Beaver Brook and continues on both sides of the highway, including the median area. Wheeler Pond, located in the NE quadrant of the Exit 4 interchange, may also require special consideration of some type to minimize impacts. Two widening concepts were developed for the Exit 4 area. Figures 4.4-21 and 4.4-22 depict the scenario which holds the western edge of the SB lanes and widens to the east to minimize impacts and reconstruction of the Exit 4 interchange. A second option, which holds the eastern edge of the NB lanes and widens to the west is described in the following sections on interchanges and is shown on Figure 4.4-45.

The width of the rail is being transitioned from a 60 ft. width to a 90 ft. width just north of Kendall Pond Road. This additional width is required to allow for the rail platform at the proposed Exit 4 station just north of the Exit 4 interchange. This additional width will also better accommodate the retaining walls, which are necessary to address grade differentials between the two barrels resulting from existing ledge scattered within this area.

4.4.1.15 From Ash Street to Stonehenge Road

This segment is surrounded by several somewhat large wetland areas on both sides of the highway, with some smaller wetland areas within the median. In addition, residential development is in close proximity to the highway both east and west of the highway. The widening generally meanders between being towards the median and towards the outside of the two barrels, in an effort to minimize and balance impacts. The median width is not overly wide further limiting options for widening. This concept is shown on Figures 4.4-23 and 4.4-24.

4.4.1.16 From Stonehenge Road to Exit 5

This segment has some wetland areas, predominantly east of the highway. The widening as shown meanders from widening to the inside to widening to the outside for both the NB and SB barrels. Ledge exists through this segment, as in previous southerly segments, and the two barrels have a grade differential of up to 10 feet through this area.

Exit 5 has also been identified as the location that the rail line may terminate or continue to the west and possibly tie into the Manchester Airport. Three different concepts have been developed to accomplish this, depending on the desired speed of the rail and the type of station accessibility preferred through this area. These concepts are shown on Figures 4.4-25 and 4.4-27.

4.4.1.17 From Exit 5 to Londonderry/Manchester Town Line

Consideration of rail is not an issue beyond Exit 5. The highway concept beyond Exit 5 and up to the Londonderry/Manchester town line basically involves widening each barrel toward the median or the outside as possible to minimize wetland impacts. The concept is depicted in Figures 4.4-26 and 4.4-28.

4.4.1.18 From Londonderry/Manchester Town Line to I-93/I-293 Split

North of the Londonderry/Manchester town line, the NHDOT is currently constructing improvements to the existing infrastructure of I-93. This project known as Manchester 12159 (I-93 over Bodwell Road and Cohas Brook) involves the rehabilitation and replacement of structurally deficient bridges at I-93 over Bodwell Road and Cohas Brook and the reconstruction and widening of 1.0 mile NB and 1.7 mile SB sections of I-93 to provide for traffic control for the bridge construction and to eliminate safety concerns at the I-293/I-93 merge and diverge areas. The work also includes the construction of 3,500 LF of sound walls and 1,800 LF of retaining walls along the west side of the SB barrel. The construction is scheduled to be completed in the Summer of 2002.

The I-93 conceptual widening alternative under consideration in this segment will be developed to utilize as much of this new construction as practicable. Special consideration will also be given to the Cohas Brook area in the median as an important wetland resource. Essentially, the I-93 widening project will add an additional lane in each direction, along the outside of each barrel, NB and SB, to the current Manchester 12159 construction limits. The widening for the SB barrel is to the west away from the median and the Cohas Brook wetland area. The widening for the NB barrel is shown to be to both the west and east, although the layout may need to be adjusted to the east to minimize impacts to the Cohas Brook wetland area. The concepts, along with the Manchester 12159 project limits are depicted in Figures 4.4-29 through 4.4-31.

4.4.2 Interchange Improvement Concepts

The following sections describe the conceptual interchange layouts for Exits 1 through 5 along the I-93 corridor.

4.4.2.1 Exit 1 – Interchange Concepts

At Exit 1, two concepts are proposed to be carried forward for further evaluation. The first essentially retains the existing ramp geometry and upgrades the existing interchange ramps. The four existing ramp structures carrying the Rockingham Boulevard over the NB and SB barrels of I-93 as they exist today will be replaced to accommodate the widening of the I-93 barrels. This concept avoids permanent impacts to the wetlands and prime wetlands adjacent to the SB interchange ramps. However, to allow for the maintenance of traffic during construction, this concept will require temporary ramp widenings, which may result in impacts on a temporary basis to prime wetland areas. The concept also maintains the existing substandard horizontal geometry of the SB off-ramp, which contains an excessively sharp curve for a high speed interstate highway. This concept is shown on Figure 4.4-32.

The second concept will improve the SB off-ramp geometry by increasing the ramp radius in keeping with modern design standards. As a result of the SB off-ramp improvements, the SB on-ramp will also require relocation to the west. This westerly shift will impact additional prime wetlands not impacted by the first concept. The NB on and off-ramps will be upgraded as required, similar to the first concept. As with the first concept, the four existing ramp structures carrying the Rockingham Boulevard ramps over the NB and SB barrels of I-93 will be replaced. This concept is shown on Figure 4.4-33.

4.4.2.2 Exit 2 – Interchange Concepts

At Exit 2, the proposed northbound ramps maintain the same basic diamond configuration that exists today. The NB ramps shift somewhat to the east to allow for the widening of the I-93 mainline and to provide reasonable separation between the improved NB and SB interchange ramp signalized intersections with Pelham Road. On the SB side of the interchange, two concepts were developed to eliminate the problematic weave motorists must negotiate between the SB off-ramp and the SB on-ramp that exists today. The first concept is similar to the NB ramp layout and involves developing diamond type ramps with a signal located at their intersection with Pelham Road. This full diamond type configuration for the interchange would result in 5 signals along the affected section of Pelham Road including: Policy Street, the NB ramps, the SB ramps, Keewaydin Drive and Stiles Road. This concept is shown on Figure 4.4-34.

The second concept for the SB ramps involves free-flow ramps for traffic on Pelham Road to travel SB on I-93. The free flow ramps would merge onto a collector-distributor traffic management lane before merging onto I-93 SB. For this second concept the SB off-ramp would shift out around the SB on-loop ramp and intersect Pelham Road at a signalized intersection opposite Keewaydin Drive. This design results in 4 signals over the affected section of Pelham Road including signals at Policy Street, the NB ramps, Keewaydin Drive, and Stiles Road. This concept is shown on Figure 4.4-35.

Pelham Road will be widened to accommodate two through-lanes in each direction with appropriate turning lanes in the intersection areas to allow for proper traffic operations.

In general, the full diamond type design would have fewer impacts because of the tighter design layout involved. Both of these concepts will be carried forward for further evaluation.

4.4.2.3 Exit 3 – 1995 Interchange Concept

A 1995 interchange layout developed as part of a study for the Windham-Salem NH 111 project was re-examined. The design concept includes a flyover two-lane off-ramp to carry the I-93 NB to NH 111 WB traffic. This ramp configuration required three bridges and a long merge area to the west for the two-lane ramp traffic and the two lanes of NH 111 WB traffic to merge from four lanes WB to NH 111's existing one lane to the west of the NH 111/Wall Street intersection. This interchange layout would basically retain the existing I-93NB to NH 111 EB off-ramp intersection in close proximity with the existing NH 111A signalized intersection. This layout is proposed to not be carried forward for further evaluation due to the greater impacts and costs associated with this design. This concept is shown on Figure 4.4-36.

Other interchange configurations for the Exit 3 area proposed for further evaluation can be best understood by looking at the three major components of the interchange area and how they connect with I-93. They include the NH 111 roadway, the SB ramps, and the NB ramps.

As discussed in Section 4.4.1.10, all concepts at Exit 3 assume the I-93 NB barrel will be shifted westerly to allow the NB ramp improvements to use the existing I-93 NB mainline footprint and provide for greater separation between the NH 111/NH111A intersection and the NH 111/NB ramp intersections. The westerly mainline shift will also allow greater flexibility in minimizing impacts to potentially environmentally sensitive resources to the east. The SB barrel for all concepts will be shifted somewhat easterly in the vicinity of NH 111 overpass to provide opportunities to develop interchange configurations and improve constructability and maintenance of traffic during construction. NH 111 would be widened to accommodate two through-lanes in each direction with appropriate turning lanes at the intersection areas to allow for proper traffic operations.

4.4.2.4 Exit 3 – NH 111 Concepts

For NH 111 through the interchange area, it will be reconstructed to provide for two through-lanes in each direction with turning lanes at the intersection areas, as necessary. Reconstructed NH 111 will generally follow the existing NH 111 alignment east of the SB barrel. However, to the west of the SB barrel, three concepts were developed as follows:

The first concept involves a continuation of the reconstruction of NH 111 on existing alignment west of I-93 SB. This concept maintains traffic on NH 111 as it passes through a residential and commercial area and in close proximity to Cobbetts Pond. The layout would have substantial impacts to properties on both sides of NH 111 west of I-93 SB. Access to some of the abutting properties would be eliminated or would be reduced to right turns-only because of a median island necessary as part of the NH 111 reconstruction. This concept is not proposed to be carried forward due to the substantial property impacts associated with this layout. This concept is shown on Figure 4.4-37.

The second concept involves a shift of the NH 111 alignment northerly approximately 400 feet, which would reduce the impacts to properties along the south side of NH 111 adjacent to Cobbetts Pond and locate NH 111 and its relatively high traffic volume further from Cobbetts Pond. The shift would increase the impacts to some of the properties on the north side of NH 111 and extend the work along NH 111 westerly beyond the NH 111 intersection with Wall Street. This concept would reconfigure the bypassed section of existing NH 111 into a frontage road. This new frontage road would dead-end just west of the new SB on-ramps and would reconnect to the new section of NH 111 opposite Wall Street to create a signalized 4-way intersection. (It should be noted that the layout for this section of NH 111 is the same layout for NH 111 that was considered as part of the study for the NH 111 Windham-Salem project.) This northerly shift will be carried forward for further evaluation in the DEIS. This concept is shown on Figure 4.4-38.

The third concept for NH 111 is a compromise of sorts between the upgrade Concept 1 and the 400-foot northerly shift for Concept 2. Concept 3 reduces the amount of the northerly shift away from NH 111 and connects the relocated portion of NH 111 to existing NH 111 east of the Wall Street intersection. A portion of existing NH 111 would still be retained as a frontage road to provide access to properties to the south along Cobbetts Pond, but the frontage road would be somewhat shorter than proposed with Concept 2. This concept will be carried forward for further evaluation in the DEIS. This concept is shown on Figure 4.4-39.

4.4.2.5 Exit 3 – NB Ramp Concepts

The northbound ramps basically involve two different configurations, as follows:

The first concept would have the NB off-ramp utilize the area currently occupied by the NB barrel of I-93. The proposed NB off-ramp would intersect with NH 111 at a signalized intersection approximately 1100 feet from the NH 111/NH 111A intersection. The ramp would operate with double left- and double right-turn lanes. The NB on-ramps from NH 111 would include a free flow loop ramp for EB NH 111 traffic and a free-flow diamond slip ramp for WB NH 111 traffic. This concept will be carried forward for further evaluation in the DEIS. This concept is shown on Figure 4.4-40.

The second concept would utilize the same NB off-ramp configuration as for concept 1, but the NH 111 EB to I-93 NB traffic would access I-93 via a signalized on-ramp, similar to the NB on-ramp layout today. This option will be carried forward for further evaluation in the DEIS. This concept is shown on Figure 4.4-41.

4.4.2.6 Exit 3 – SB Ramp Concepts

The southbound ramps involve two different configurations, as follows:

The first concept would create a standard diamond ramp layout for the SB off and on-ramps with a signal at the intersection of the ramps and NH 111. This concept is shown on Figure 4.4-42.

The second concept involves free-flow ramp layouts for eastbound and westbound NH 111 traffic that desires to travel south on I-93. The two ramps merge to form a single ramp (or traffic management lane) that then merges with the mainline. The SB off-ramp would intersect NH 111 at a new signalized intersection. This concept is shown on Figure 4.4-43.

The diamond type ramps would have fewer impacts than the loop concept because of the tighter design layout involved, but the free flow concept would provide better operation, an important consideration given the high volume of southbound oriented traffic. Both of these concepts will be carried forward for further evaluation.

4.4.2.7 Exit 4 – Interchange Concepts

Two concepts were developed for Exit 4. Both options retain the same general ramp configuration as the existing interchange layout. The options include a westerly I-93 widening concept and an easterly I-93 widening concept as related to the I-93 mainline. These concepts are depicted in Figures 4.4-44 and 4.4-45.

The easterly widening concept would hold the existing west edge of the SB mainline barrel and widen I-93 easterly to minimize the reconstruction of the existing SB ramps and eliminate the substantial amount of ledge/rock excavation that would be necessary with a westerly widening concept. The existing NH 102 roadway would be widened and the NH 102 bridge over I-93 would be replaced with a wider and longer structure to accommodate the need for additional lanes along NH 102 and the need to span over the widened pavement of I-93 and the rail corridor in the median. A detour bridge adjacent to, and just south of, NH 102 would be required during construction of the new bridge. This concept will impact the wetland areas adjacent to the sewage treatment plant to the south of Exit 4 and Wheeler Pond to the north. Retaining walls will be necessary to reduce or eliminate these impacts. This concept will be carried forward for further evaluation in the DEIS.

The westerly widening concept would hold the east edge of the existing NB barrel with all widening occurring to the west side of I-93. This concept would require the WB NH 102 to I-93 SB ramp and the I-93 SB off-ramp to be reconstructed. NH 102 roadway would be realigned to the south of existing NH 102 to provide for the geometry of the SB loop ramp. In doing so the existing bridge and approaches can maintain traffic while a new wider and longer NH 102 bridge and approaches are constructed. This option would reduce or eliminate impacts to the wetland areas near the sewage treatment plant and Wheeler Pond along the east side of I-93 and reduce the need for the construction of retaining walls. However, this concept would require extensive ledge removal to accommodate the reconstruction of the SB ramps. This option will be carried forward for further evaluation in the DEIS.

4.4.2.8 Exit 5 – Interchange Concepts

At Exit 5, three interchange concepts were developed. For all three concepts the diamond type ramp design for the SB on and off-ramps are identical. For two of the concepts the NB diamond type ramp layouts are the same, but the geometry of NH 28 east of the NB ramps varies. Each of these three concepts will be carried forward for more detailed evaluation in the DEIS. The concepts are depicted in Figures 4.4-46 and 4.4-48.

The first interchange concept shows NH 28 on the east side of Exit 5 as realigned to replace the existing reverse curves with a simple curve. NH 28 will be widened to 6-lanes through the interchange and transitioned down to a 5-lane section through the Liberty Drive intersection before transitioning back down to a two-lane section approximately 1000 feet south of Liberty Drive. This realignment reduces potential impacts to properties along the east side of NH 28 between Auburn Road and the relocated Liberty Road intersection with NH 28. This concept would substantially impact properties located on the west side of NH 28 along the inside of the relocated curve. To the west of the Exit 5 interchange, the 6-lanes in the interchange area will transition to 5-lanes through Perkins Road and then transition to the existing NH 28

2-lane section. Perkins Road would be reconstructed to some degree to better align with the entrance to the transfer station driveway on NH 28.

The second interchange configuration concept shows NH 28 east of I-93 would generally retain the existing alignment along NH 28. This concept utilizes the same ramp improvements identified under Concept 1. This concept reduces impacts to the properties along the west side of NH 28 along the inside of the curve, however properties along the east side of NH 28 in the vicinity of Liberty Road and Auburn Road intersections would be impacted by the split widening along NH 28. Treatment of NH 28 west of the NB ramps would be similar to what is proposed with concept 1.

A third interchange concept for Exit 5 would again retain the SB ramp configurations as proposed in Concepts 1 and 2, and the NH 28 alignment as in Concept 2, but the NB ramps would be relocated to the south of the existing ramps and intersect along NH 28 further to the south. This design would realign the NB ramps to one major intersection opposite the recently constructed NH 28/Liberty Drive intersection. This concept would provide additional separation from the NH 28/SB ramps and direct access to an industrial area being developed off Liberty Road. This concept would impact some wetlands southeast of the interchange, but possibly reduce impacts to wetlands in the NE quadrant of the Exit 5 Interchange. This concept would extend property impacts along NH 28 frontage to the south.

4.5 Transportation System Management Alternatives

Transportation Systems Management (TSM) refers to short range, moderate cost measures aimed at reducing congestion and enhancing safety on the existing transportation system or roadway network. Generally, these measures involve little or no right-of-way impacts. Such measures might include traffic signal timing or phasing modifications, adding or extending turn lanes within the existing right-of-way, the restriping of existing pavement markings, or the introduction of turn restrictions. This section includes specific TSM improvements that will be further investigated for the I-93 project and discussions on ramp metering and shoulder lane use as possible TSM options.

As previously stated in Chapter 2, TSM improvements would not address the long term safety and capacity needs of the highway, but could provide some short term relief in advance of the ultimate highway improvements.

4.5.1 TSM Improvements

This section describes a series of TSM actions that are aimed at addressing immediate safety or operational deficiencies along the I-93 corridor. For the most part, the TSM actions are concentrated at the corridor interchanges. The TSM areas are depicted in Figure 4.5-1.

The relatively short length and steep grade of the northbound on-ramp at Exit 2 can be problematic. The ramp grade (approximately 4 percent) combined with the relatively high percentage of truck activity (11 percent in the morning peak hour) can result in congestion and create a potentially hazardous condition as motorists caught behind slow moving trucks attempt to pass trucks at the gore area in an effort to enter the highway. In addition, the signalized northbound and southbound Exit 2 ramp intersections with Pelham Road, as well as the nearby intersections of Pelham Road with Keewaydin Drive and North and South Policy Street, currently operate at or close to capacity.

To address the deficiency at the Exit 2 northbound on-ramp (Figure 4.5-2) a recommended TSM option would be to extend the northbound on-ramp to provide greater distance and time for truck traffic to get up to speed before entering the highway. Note that this action will not address the LOS F operation of the merge movement during the PM peak hour, but would enhance the safe and efficient operation of the ramp merge.

In addition to the extending the northbound ramp, there are plans to upgrade Pelham Road. The Town of Salem, with participation from the State, proposes to upgrade Pelham Road at the Exit 2 interchange (Figure 4.5-2) in 2001. These improvements include widening Pelham Road to a 4-lane section and upgrading the Pelham Road/Keewaydin Drive/SB ramp intersection, the Pelham Road/Stiles Road/Manor Parkway intersection, and the Pelham Road/NB ramps intersection. These improvements would add one additional lane (resulting in a four lane section) along Pelham Road through these intersections to provide for more traffic throughput at the intersections. Pelham Road, between the interchange intersections, would consist of two through lanes in the westbound direction, and a single through lane and an exclusive left-turn lane in the eastbound direction. A 2 to 4 foot shoulder would be provided on each side with a 5-foot sidewalk along the south side of the roadway. These improvements would substantially improve the operating conditions along Pelham Road over the near term.

At Exit 3, the intersections of NH 111 with the northbound and southbound ramps currently operate at capacity during the PM peak hour. The proximity of the NH 111A intersection to the NH 111/ Northbound ramp intersection combined with the capacity constraints of the NH 111/Northbound ramp intersection results in substantial delay and long vehicle queues along NH 111 and along the Northbound off-ramp. In addition, unsignalized left-turn exiting movements from the southbound off-ramp onto NH 111 operate at LOS F with long delays. However, the relatively low left-turn volume (75 vehicles during the AM peak hour and 70 vehicles during the PM peak hour) makes it difficult to justify the installation of a traffic signal.

To address the deficiency at the Exit 3 northbound ramp (Figure 4.5-4) a recommended TSM option would be to widen the off-ramp to provide a double left-turn lane. This improvement is currently under design as part of the NH 111 Windham-Salem project. In addition, improved traffic signal coordination should be provided between the northbound off-ramp signal and the signal at the NH 111A/NH111 intersection. With these improvements, the northbound off-ramp intersection would operate at LOS C in the PM peak hour.

At the southbound ramps (Figure 4.5-5) a recommended TSM option would be to extend the right-turn lane on the NH 111 eastbound approach to the intersection to better delineate and channelize the right-turn movement. This action would allow motorists who are turning left onto the southbound on-ramp to better distinguish the eastbound right-turn movements from the eastbound through movements. This improvement would enhance the safe and efficient operation of the intersection. In addition, the acceleration lane where the southbound on-ramp meets I-93 could be extended (Figure 4.5-6) to improve the merge between the ramp and the mainline. Installation of a traffic signal at the SB off-ramp/NH 111 intersection is not proposed as a TSM option because of traffic volumes on the ramp are relatively low and the WB approach on NH 111 does not have enough room to provide two through lanes and an exclusive left-turn lane required to keep the intersection operation acceptable.

At the Exit 4 Interchange, the signalized northbound and southbound ramp intersections with NH 102 operate at acceptable levels of service. However, during the evening peak hour the NH 102 eastbound left-turn movement at the intersection with the northbound on-ramp can experience queues that exceed the available storage. A recommended TSM option would be to extend the storage for the left turn lane be approximately 300 feet (Figure 4.5-7). This can be accomplished by modifying the existing raised median.

The signalized northbound and southbound ramp intersections at Exit 5 operate at capacity during the peak hours of the day. Motorists experience delay on all approaches. However, from a safety perspective, the immediate need is to address the existing problem of vehicles queuing back onto the I-93 southbound mainline from the southbound off-ramp. During the weekday PM peak hour, vehicles often queue back onto the shoulder area along the I-93 southbound approach to the off-ramp.

To address the queuing problem at the southbound off-ramp (Figure 4.5-8) a recommended TSM option would be to lengthen the ramp and widen the shoulder area approaching the off-ramp to provide additional storage for these vehicles. This option would likely require some widening of the existing railroad bridge just north of the SB off-ramp to accommodate a longer ramp and allow for proper separation of exiting and through vehicles. Retaining walls and special slope treatments would also be required to minimize impacts to surrounding wetlands. Once the long-term solution has been identified in sufficient detail, further study will be required to develop a short-term solution, so a phased approach could be incorporated.

It is also recommended (Figure 4.5-9) that the signal timing at the interchange intersections be modified to provide additional green time to the off-ramp movements. Loop detection could be placed at the beginning of the off-ramp to detect the presence of queued vehicles and enhance the operation of the ramp intersections.

4.5.2 Ramp Metering

The primary object of any freeway control technique is to improve the safety and efficiency of mainline freeway operations by reducing the factors that increase freeway congestion. One method in freeway traffic control is freeway entrance ramp metering, commonly known as ramp metering. Ramp metering controls the access of vehicles into the mainline flows so that the vehicles entering upstream of the area of traffic flow to be managed are approximately proportional to the vehicles exiting downstream of the area. The purpose is to regulate freeway demand so that demand does not exceed highway capacity.

Control is provided via signalized entrance ramps which delay drivers entering the highway so that flow on the highway can be maintained at an acceptable level of operation. Ramp metering balances the overall traffic flow by regulating ramp demand in proportion to freeway capacity. Drivers trying to enter the highway must wait in the resulting queue and may be encouraged to find either another:

- point of entry,
- route,
- time to enter the freeway, or
- transportation choice.

Entrance ramp control operations can be subdivided into two main types, known as 'pre-timed metering' and 'traffic-responsive metering'[13]. Pre-timed metering is the most common form used to improve merge operations onto the freeway. In the case of pre-timed metering, the ramp meter rate is set as the difference between

[13] Transportation and Traffic Engineering Handbook, ITE, Chapter 25, pages 786-798, 1982.

downstream capacity (vph) and upstream demand (vph), based on historical volume data[14].

Traffic-responsive metering differs from pre-timed ramp metering in that the ramp meter rate is reflective of the current available capacity, which is based on 'real-time' monitoring of upstream and downstream traffic flows. Additional vehicle detectors placed either before the ramp meter for queue detection or after the meter for monitoring merge conditions can increase the efficiency of the meter operations. For example, to keep the ramp queues from extending onto local roads, vehicle queue sensors would increase meter rates in order to balance ramp demand with queue storage. When several meters are linked together, the ramps respond to the entire freeway condition rather than the local condition, this is known as an 'integrated system control'. ITE[15] studies have shown that responsive metering connected to a central control station can result in lower travel times, fewer crashes and higher total travel.

Alternative transportation choices are encouraged by exclusive HOV lanes, which allow HOVs to bypass the ramp queue. This is known as priority access control and it encourages carpools, vanpools, and transit use. Encouraging these travel modes has the net effect of lowering overall vehicular demand on the freeway while still serving the same number of people.

4.5.2.1 Findings

There are several advantages offered by ramp metering. The regulation of vehicles entering the main line flows presents drivers with a set of consistent operation parameters that they can easily adapt to and provide the following benefits:

- More consistent freeway flow speeds, which result in less air pollution.
- Utilizing freeway corridor capacity more efficiently by eliminating bottlenecks at ramp entrances, where heavy entering traffic disrupts mainline flow.
- Reducing the number of congestion related collisions that occur when drivers are forced to compete for gaps in the traffic flow.
- In the case of traffic response metering, there is an added benefit of being able to respond to variable conditions such as a weather or traffic incidents.
- An integrated system optimizes the traffic flow over an entire corridor thereby increasing efficiencies at the local level as well as over the entire system. If traffic response metering is utilized, traffic flow through the entire system could be optimized for the given capacity.
- Vehicle queue sensors would increase meter rates and balance ramp demand with queue storage thereby reducing spillover to local roads.

▼
[14] Same as above
[15] Same as above

Disadvantages of ramp metering include:

- Limited freeway entrances could cause substantial queues at metered entrance ramps because of lack of alternative routes. If there is inadequate storage area, such queuing may extend onto local roadways and interfere with non-freeway traffic.
- Increased delay at metered ramps may divert traffic to other ramps and roadways, shifting congestion to other locations.
- Increased delay at metered ramps may divert traffic to travel at a different time of day, extending the hours of congestion and inconveniencing drivers.
- Existing interchanges with insufficient geometric capacity may require costly upgrades to provide sufficient storage capacity to prevent queuing onto local roadways.
- The need to provide enforcement of ramp meters to prevent cheating that will reduce the effectiveness of the meters.

According to the Manual on Uniform Traffic Control Devices, there has been insufficient experience with ramp metering to permit development of numerical warrants applicable to the wide variety of conditions found in actual practice. However, guidelines have been suggested for successful application of controls. Installation of freeway entrance ramp controls may be warranted when:

- The reduction in freeway delay exceeds the delay to ramp users and drivers on alternative routes.
- There is adequate storage space for queued vehicles
- There are suitable alternative routes
- There is recurring freeway congestion due to demand exceeding capacity or there is recurring congestion or accident hazard at the freeway entrance because of an inadequate merge area.

4.5.2.2 Recommendations

Ramp metering along the I-93 corridor between Manchester and Salem would not provide an effective method of improving traffic operations throughout the corridor. In general, it would only be potentially effective in addressing morning peak period congestion when more traffic generally enters the highway than exits at each interchange. In the evening, the reverse is generally true and except at Exit 1, entering traffic does not generally add to the mainline congestion.

Ramp metering is generally used in urban areas where alternative travel routes are available. The principal drawback to ramp metering on I-93 in New Hampshire is that there is a limited number of access points to I-93, and thus alternatives are limited for drivers facing long queues at metered ramps. Any diversions that do take place will only serve to move congestion to new locations. To the extent that there is no diversion, many ramps would have inadequate storage space to accommodate queued vehicles. This would result in queues extending to local roadways and interfering with non-interstate related traffic.

Another alternative for drivers would be to change their travel time. However, since I-93 now experiences a three-hour peak period, the opportunities for altering the timing of travel to avoid delay are limited.

The final option for drivers would be to change mode of travel. As the ridership analysis presented in Chapter 5 demonstrates, there is only a limited number of commuters that could be served by alternative modes. Even if such alternative modes are expanded or added, many commuters travel to locations that would not be served by any of the alternative modes considered in this study.

4.5.3 Shoulder Lane Use

The use of shoulders, or breakdown lanes, as travel lanes has been in existence in the United States since the late 1960s. More than 24 states have implemented projects involving the use of shoulders as a means of providing additional travel lanes and capacity since that time. Typically, opening shoulder lanes for travel during peak hours is primarily viewed as a temporary solution to peak period congestion until the permanent solutions are constructed.

Using the existing shoulders along I-93 in New Hampshire as a travel lane was looked at as a possible short-term TSM option to help relieve congestion during the peak travel period of the day. Based on a review of the existing traffic operations for I-93, the area that was of particular interest to evaluate the use of a shoulder lane treatment to reduce congestion during the evening peak period was the northbound section of I-93 between Exit 1 (Rockingham Boulevard) in Salem and Exit 3 (NH 111) in Windham, a distance of 3.9 miles. This section of the I-93 NB barrel consists of four lanes south of Exit 1 and two lanes immediately north of Exit 1 and this narrowing of the highway in conjunction with the short distance between interchanges make this section of I-93 particularly susceptible to congestion. There are three interchanges in this segment and the posted speed limit is 65 miles per hour (mph) north of Exit 1 and 55 mph south of Exit 1.

4.5.3.1 Implications for I-93

Accommodating the use of the shoulder along I-93 northbound between Exits 1 and 3 for peak period travel would require widening the entire 3.9-mile corridor to provide a minimum 12-foot shoulder. Furthermore, additional widening in specific locations would be necessary to provide sufficient clear distance from obstacles along the edge of roadway and to provide for emergency vehicle pulloffs.

In addition to the mainline treatment, there are four bridges that would need to be widened, and three where modifications to elements (stone aprons, guardrail or concrete barrier) beneath the bridges would need to be modified to provide the necessary highway width to allow traffic to utilize the shoulder as a through lane during peak periods of congestion. In total, the highway width would be a minimum of 42 feet wide to accommodate a 4-foot median shoulder, two 12-foot travel lanes, a 12-foot shoulder lane, and a minimum 2-foot offset to a guard rail or concrete barrier.

4.5.3.2 Findings

A review of the shoulder use issue and existing conditions along I-93 north from the Massachusetts/New Hampshire border to Exit 3 include the following:

- Safety statistics associated with other locations, where the shoulder is used as a means of increasing capacity, indicate that there is a general statistical increase in traffic accidents associated with the usage of the shoulders as travel lanes. However, as drivers become more familiar with the use of the shoulder as a travel lane, accident rates decline over time (although accident rates remain higher than pre-usage periods).[16]

- As noted in the *Scoping Report*, the existing traffic volumes and operations indicate that I-93 within the study area is currently over capacity. This congestion suggests that the corridor could benefit from peak period use of a shoulder lane as a temporary traffic management solution. However, as described below, given existing physical constraints along the corridor, this is not a quick or low-cost alternative.

- Based on the recommended minimum cross-sections, there is inadequate width to accommodate the proposed use of the shoulder over the 3.9 miles between Exits 1 and 3, without widening the entire roadway corridor by an average of two to four feet.

  Much of the widening for the shoulder lane between Exits 1 and 2 would also require additional widening beyond the shoulder lane pavement to accommodate guardrail due to the steep fill slopes. This widening would result in impacts to wetlands, including prime wetlands, adjacent to I-93. The section of I-93 between the Pelham Road bridge and the Brookdale Road bridge (approximately 3000 feet) will require additional widening due to the narrowness as the Exit 2 NB on-ramp merges with the mainline. The NB on-ramp at Exit 2

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[16] Report 369 - Use of Shoulders and Narrow Lanes to Increase Freeway Capacity; National Cooperative Highway Research Project, Transportation Research Board; Washington DC 1995
Safety Implications of Using Highway Shoulders as Travel Lanes; Alicia Powell Wilson, Central Transportation Planning Staff; Boston, Massachusetts; April 1997.

would also require reconstruction to accommodate the additional width for the shoulder lane.

Based on the AASHTO recommended minimum pavement cross-section, the I-93 NB bridges over Porcupine Brook, NH 38, Pelham Road, and NH 111-A between Exit 1 and Exit 3 would require widening of approximately four feet to accommodate the 42-foot of width criteria.

At the Brookdale Road bridge over I-93 NB, the existing 10 foot shoulder under the bridge would require widening and modifications to accommodate the installation of guardrail or barrier protection to allow for the use of the shoulder lane.

In the area of the two Rockingham Boulevard bridges over I-93 NB, the existing 11-foot inside shoulder would need to be widened one foot and the existing guardrail replaced with a concrete barrier offset at two feet from the inside shoulder.

Pulloff locations for emergency situations when shoulders lanes are in use would be required. By using the shoulder as a through lane, the ability for vehicles to exit the travel way under emergency conditions is limited. As a minimum, emergency pulloff areas would be provided every 2,500 feet. The pulloffs would require additional highway widening potentially creating additional resource and property impacts.

Additional clearance to fixed objects on the side of the roadway would also need to be provided. Guardrails and barriers must have a 2-foot minimum clearance from the edge of pavement, while breakaway signs require 6-feet of clearance.

- The close proximity of the interchange spacing between Exits 1 and 2 would reduce the effectiveness of shoulder lane operating conditions and increase safety concerns associated with traffic exiting and entering I-93 in this area.

- The existing horizontal and vertical geometry in the section of I-93 between Exits 2 and 3 is not desirable for shoulder lane use. The 4-5 percent grades in combination with near maximum roadway design curvatures further compromise safety relative to shoulder lane use.

The implementation of shoulder lanes north of Exit 3 and along the SB barrel of I-93 between Exits 1 and Exit 5, although not fully evaluated, would face similar difficulties as discussed in the preceding text. The need to widen bridges, improve clear zone offsets, and provide for emergency pulloffs would be similarly problematic.

4.5.3.3 Recommendations

The existing cross-section along the entire 3.9-mile section of the I-93 northbound barrel between Exits 1 and 3 would require some amount of geometric improvements prior to utilizing the shoulder as a means of providing additional capacity. The construction activities and improvements associated with the widening of the corridor and the widening and/or modification of seven bridges would require a substantial capital investment and environmental coordination and permitting. While utilizing the shoulder lane as a means of increasing the capacity of the corridor would help in the near-term, it should be viewed as a temporary solution only. The construction activities, including traffic control, necessary to complete the construction of the shoulder lane would further disrupt the existing traffic flow and further increase congestion for, in all likelihood, a two-year construction period. The actual use of the shoulder lane, once completed, may have only a one or two year life with the more permanent solution being contemplated to begin construction in 2004. The capital investment needed to meet the current AASHTO standards for shoulder lane use would be better spent on a more permanent transportation solution, with the completion of the section of I-93 between Exits 1 and 3 given a priority.

For these reasons, it is recommended that the use of the shoulder as a means of increasing capacity along I-93 northbound between Exit 1 and Exit 3 be discontinued from further consideration.